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INSTALLATIONS AND PRODUCTION OF CZECH STALIN WORKS SYNTHETIC GASOLINE PLANT

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/Information on graphics material is appended./

Immediately after occupying Czechoslovakia the Germans began construction, in May 1939, of a synthetic gasoline plant in the vicinity of Most. When completed, this factory was to produce one million tons of fuel per year.

The process of making the gasoline employs hydrogenation of coal tars contained in abundance in local brown coal ("Hedvika" coal 14.3 percent, "Kolumbus" 11.7, "Quido I-III" 13.0, "Centrum" 12.1; average, approximately 13 percent), rather than direct hydrogenation of pulverized coal. Brown coal is transported to the plant in 60-ton "Talbot" railroad cars. The coal is crushed and graded. Coal chips and dust serve as fuel for the plant's electrical power center, which also supplies hundreds of thousands of kilowatt-hours daily to the Ervenice electrical works, and to the brown-coal mines of Eastern Czechoslovakia.

Graded pieces of coal, 8-16 mm in diameter, are pressure-distilled to produce illuminating gas, which supplies the 135 km pipeline running along the border to Varnsdorf and Zheleznyi Brod. This gas supplies 35 cities, many glass factories, and other enterprises. Preparations are being made to distribute gas generated at the Stalin Works to Prague and to cities situated along the pipeline which lack gasworks.

Coal particles larger than 16 mm are distilled at 700° C /Centigrade used throughout/ in a Lurgi distiller, consisting of a vertically arranged drying chamber, (through which the coal passes first) on top of an aluminum Fischer-type carbonizing retort. Heat for the drying and distillation is provided by burning part of the gases produced in the distillation process in burners located

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outside the coal-filled chambers. Two ventilators, one pusher, and one exhaust provide draft for the smoke gases passing through the dryer. A flushing gas is also passed through the carbonizer. The hot gas passing through the coal permits distillation of 90 percent of the tar at 700°. The annual average moisture content of the coal is 29 percent. (Photograph No 1.)

Tar is recovered in three stages: heavy tar from the air cooler (sg 1.053, congelation point 41°), "electrotar" from the electrostatic tar precipitator (sg 0.999, congelation point 27°, phenol content 20 percent); and middle oil from the water cooler (sg 0.993, congelation point 6°, phenol content 29 percent). Benzine is scrubbed out of the distillate gas with the aid of the tar-oil. The brown-coal coke which is removed at the bottom of the carbonizer is cooled with carbon dioxide and graded. The composition of the dried brown-coal coke is the following: ash 17-20 percent, carbon 72-73 percent, hydrogen 1.5-1.7 percent, sulfur 0.7-1.4 percent, and nitrogen 0.9-1.0 percent; heating value 6,400-6,620 calories. Part of the coke is used for producing hydrogen; 30 percent is sold as smokeless /household/ fuel. It is interesting that with a decrease in the size of the coal pieces, heating value decreases and the ash increases.

The coke is distributed to Sweden, Switzerland, and Denmark, as well as within Czechoslovakia.

As soon as the temporary coal shortage ends, the demand for smokeless fuel will again rise, and the manufacture of coke will gain increased importance. The manufacture of coke is important also from the point of view of public health, since coal tar and coal smoke are known to contain carcinogenic hydrocarbons (methyl cholanthrene), and the highest incidence of cancer is in cities heavily polluted with smoke.

Another distillation product is the aqueous distillate (12-15 percent of the weight of the coal), which contains 8 g NH_3 per liter, 10 g phenol, and approximately the same amount of diphenols (pyrocatechol and homopyrocatechol) and other homologues. The aqueous distillate also contains acid oils, ketones, and other yet undetermined compounds. This aqueous distillate, which is produced in large quantities, represents a rich source of aliphatic and aromatic compounds.

The distillate gases are used as fuel for the distilling ovens, for the tar-distilling process, and for firing the boilers of the electric power plant. The gas contains approximately 45 percent nitrogen and 8-11 percent CO_2, giving it a heating value of a little less than 2,000 calories.

Hydrogenation

The tar produced by the Lurgi distiller, tar produced in the generators, which formerly was burned as waste, and perhaps some impure tar are centrifuged twice in Escher-Wyss, or Haubold horizontal-axle centrifuges, to remove large and small suspended particles.

The lower boiling fraction (up to 320°) is first distilled off in a pipe still and added to the middle-phase mixture. The tar boiling above 320° is passed through two heat exchangers, mixed with fresh and recovered catalyst, and fed by piston pumps into four 1 x 18-meter cracking columns made of nickel-chrome alloy steel. The product is passed through a hot precipitator and through the regenerator to the coolers and decompressors. The mixture entering the heavy phase reactors usually contains no fraction boiling under 180°, and approximately 8-10 percent may be distilled off up to 335°. Of the product leaving the heavy-phase reactors, approximately 10 percent distills off below 200°, and at least 65 percent below 360°. The high-boiling residual tars are again added to the mixture entering the heavy phase tower. In addition to liquid products, some gas, consisting of methane, ethane, propane, butane, and isobutane, is produced in each phase chamber. The most gas is produced in the heavy-phase tower.

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Middle-Phase Chambers

The phenol contained in the tar (20 percent) is removed in the four middle-phase reactor columns. Here the tars are cracked and refined, and oxygen, nitrogen, and sulfur are released as water, ammonia, and sulfur-hydrogen compounds. The raw material for the middle-phase chambers consists of middle oil boiling under 320°, middle oil from the electrostatic tar precipitator, and middle oil from the heavy-phase towers. In the middle-phase chambers, the specific gravity of the tar mixture is reduced from 0.935 - 0.925 to 0.800, and the quantity of the fraction boiling under 200° increased to 30-35 percent. The middle-phase products are separated in a pipe still, producing first gasoline and diesel oil, of which the latter is the raw material for the light-phase reactor.

Light-Phase Chambers

The light-phase cracking column produces gasoline from diesel oil and kerosene. By simply passing the tar mixture through the column, one can produce gases and also a liquid which is 30-70 percent gasoline. By using fresh catalyst, one can produce a liquid which is up to 30 percent gasoline.

The light-phase columns are filled with disks of 10 percent WS_2 on fuller's earth (actually aluminum silicate). The Germans designated this catalyst with the number 6434. In the middle-phase chambers, disks of 100 percent WS_2 were used, identified by the number 5058. Later, because of a shortage of WS_2, a new catalyst mixture was used, consisting of 30 percent WS_2, and three percent nickel sulfide, on aluminum oxide. This catalyst (Number 8376) proved to have advantageous refining characteristics in the middle-phase cracking process. In all except the heavy-phase reactors, fixed catalyst, in the shape of disks, is used. In the heavy-phase columns, the catalyst consists of iron sulfide precipitated onto fine particles of a carrier substance, and is mixed with the distillate residue, to be added to the tar mixture.

Hydrogenation is carried out at 320 atmospheres. The temperature is highest in the heavy-phase reactor (about 500°). The optimal hydrogenating temperature is established by trial and error for each raw material, the temperature being based on the ratio and quantity of the liquid and gas products.

Part of the heat for the hydrogenating chambers is supplied in the heat exchangers, by the hot departing products. This is supplemented by gas-burning preheaters. Only the raw material for the middle-phase reactors is preheated electrically. This preheating is necessary to start the reaction, although much heat is liberated in these reactors during the course of the process. The optimal temperature is maintained either by adding cold hydrogen to the reactors, or by increasing the temperature of the preheaters.

The hydrogen added in the process is 98 percent pure, containing 2 percent nitrogen, and traces of CO_2. Gas liberated in the process consists of 6-60 percent hydrogen, 12-25 percent methane, 7-15 percent ethane, 4-24 percent propane, 0.5-5 percent butane, and one to 15 percent C_5 hydrocarbons.

Hydrogen Production

The hydrogen for hydrogenation (about 1,000 cu m per ton of gasoline) is made from water gas, which is produced in large capacity Winkler generators (20,000 - 25,000 cu m hr). Approximately 1,200 cu m of gas (CO plus H_2) are produced from one ton of coke, requiring 0.33 normal cu m of 98 percent pure O_2 per cubic meter of gas produced. Approximately one kg per normal cu m of steam is required for the production of /water/ gas. (Photograph No 2.)

Coal particles of less than 6 mm diameter are fed into the Winkler generator by a carrier belt from the hopper. The coal particles are kept suspended in the burner by a blast of water gas and oxygen from under the grate. Suspension of the coal particles is aided by circulation of part of the water gas (0.16 cu m per cu m). The generator's 30-meter-high cylindrical ash chamber has two openings at the bottom, where ash is removed on a carrier belt.

The chief advantage of the Winkler generator is its capacity: approximately 700-1,100 kg fuel per sq m per hour. Its chief disadvantage is the high velocity of the gas stream, which carries coal and ash particles into the boiler that utilizes the heat of the produced gas, into the cooler, and the Theissen washer, and results in considerable waste of fuel, as well as erosion of the equipment. Coal and ash particles are removed partially by cyclone precipitators. A considerable amount of unburned fuel is contained in the ash mixture, probably in the form of incompletely burned coal particles, but is not satisfactory for use in powdered coal burners.

The coal is 77-78 percent consumed in the generator. The composition of Winkler generator gas is the following: CO_2 25-26 percent, CO 29-30 percent, H_2 40-41 percent, and N_2 plus CH_4 3 percent.

Hydrogen sulfide (6-7 g per normal cu m) is removed from the water gas by binding it with an iron hydroxide, a waste product of alumina production. The gas is compressed to 10-12 atmospheres in the low-pressure portions of the hydrogen compressors. The compressed gas and steam are fed into 15-meter high saturation towers, which are packed with ring-shaped elements. The gas then passes through a preheater heat exchanger, and into the converter, where hydrogen is produced according to the reaction CO plus $H_2O \rightarrow CO_2$ plus H_2, at 450-550°, with the aid of iron oxide - chromium oxide catalyst. (Photograph No 3.)

The CO_2 is washed out with water and the water pumped into an expansion tower by a turbine pump. A low-pressure pump returns water from the expansion tower, to a high-pressure pump which is coaxial with the turbine, and the water is fed back into the top of the washing column. Previously, CO_2 produced in this process had been used only as a protecting gas, although it could be better utilized for other purposes; as, for example, in the manufacture of urea.

Stabilization

Residual gas is finally separated from the liquid product in the rectification stage. (Photograph No 4.)

Since the liquid products are saturated, and practically free from sulfur and nitrogen compounds, the liquid need not be refined with sulfuric acid; alkaline rinsing and washing with water are sufficient. Only gasoline intended for pharmaceutical use is refined with H_2SO_4, to remove aromatic hydrocarbons.

The hydrogenation products are exceptionally stable in regard to storage. No inhibitor need be added, as in the case of gasoline produced by cracking. The octane rating of gasoline produced by hydrogenation depends on the raw materials used, but is not less than 55, even for gasoline produced from "pakura"/low grade peat?/. Gasoline produced from tars has an octane rating of 70-72. Gasoline from crude oil is 42-45 octane, and cannot be raised to 72 even with the addition of benzene. To raise the octane rating to 67, tetraethyl lead must be added to the gasoline. Reports of the bad quality of synthetic gasoline are false. Neither gasoline produced by the distillation of crude oil nor by cracking has the quality of synthetic gasoline.

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The gases produced during hydrogenation are dried with silicagel and are pressure-distilled in four columns, producing nearly pure gases: ethane, which is used in refrigerators operating as low as -80°; propane, which is used for asphalt extraction in the production of lubricants; and motor fuel gas, which is composed of up to 15 percent ethane, up to 56 percent propane, up to 56 percent butane and isobutane. The heating value of motor fuel gas is greater than 25,000 cal/normal cu m, and its octane rating is above 100, which makes it an excellent motor fuel. In the future, liquid gas certainly will be distributed extensively in rural areas, where sparse settlement makes illuminating gas pipelines impractical.

Heat Energy Balance

Considering the proportion of the total energy expended which is required merely to dry the coal, the value of the hydrogenation products makes the above coal distillation process very advantageous. This may be asserted on the basis of 1946 production figures of the Stalin Works, even though the 1946 figures were not outstanding, and war damage to the plant, which had been hit by 16,000 bombs, had not yet been completely repaired.

Taking the calory content of coal, crude oil, "pakura," and tars entering the plant as 100 percent, the calory content of products leaving the plant is expressed in the following percentages: motor fuels 16.031 percent; coke 22.942 percent; illuminating gas 1.482 percent; electric current 1.122 percent; steam (for the mines) 0.170 percent; solvents 1.301 percent; hydrogenated crude oil 0.137 percent; bottled hydrogen 0.01 percent; total 43.186 percent.

Many products are not accounted for in the materials or heat-energy balances; e.g., the phenols, which are extracted from the water distillate by butyl acetate. Monophenols are basic materials of the pharmaceutical, paint, plastics, and synthetic resins industries. Polyamides [resins?] are also produced from monophenols. Diphenols also will become important raw materials of the chemical industry in the near future. Up to the present, diphenols, and especially pyrocatechol have not been sufficiently valued as raw materials in our country. More extensive use of diphenols has been hindered by their high cost (250 Czech crowns per kg), which is due to the expense of synthetic production. The water distillate makes possible the production of tens of thousands of tons of diphenols, as well as phenols, cresols, and their homologues.

During World War II, the Germans shipped phenol from Most to Hoechst and Ludwigshafen, for the manufacture of synthetic resin. Synthetic resin of the type previously manufactured from monophenols can only slightly replace natural resin. Relatively brief research was required for us to develop production of synthetic resins which in many respects are superior to imported, natural resins.

Resins with high ion-exchange capacity (for water softening), and which are derivatives of pyrocatechol have not yet been produced in this country.

Conclusion

The selling price of gasoline is high, but even if gasoline were given away free at the gates of the Stalin Works, it would still cost 4.96 Czech crowns per liter.

The increasing demand for gasoline and the shortage which already is being felt, is forcing even the US to deal seriously with the production of gasoline from coal. In the US, they are preparing to establish a synthetic gasoline heavy industry through extensive laboratory and experimental industrial work in which not only the state, but private firms also are participating. The fact that US oil firms are purchasing coal mines indicates a new trend in gasoline manufacture. Synthesis of gasoline from water gas, and the hydrogenation of coal are two trends being seriously pursued in the US.

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GRAPHICS MATERIAL AVAILABLE

Requests for copies of, or further information on, the photographs described herein should be addressed to Graphics Register, CIA, by referring to report number and item number.

1. Location: Czechoslovakia, Most, Stalin Works Synthetic Gasoline Plant

   Caption and Description: "Coal Distillation in Flushing-Gas Retorts Housed in the Building. In Front of the Building Are the Electrostatic Tar Precipitator, Coolers, and Martin-Huenecke Washer." View of factory building, silhouette, and position of installations

   Photograph Description: Size, 2½ x 3 inches; fair; slick

   Source: Magyar Kemikusok Lapja, Budapest, Vol VII, No 8, August 1952, page 227

   Repository of Source Document: CIA

2. Location: Czechoslovakia, Most, Stalin Works Synthetic Gasoline Plant

   Caption and Description: "Winkler Generator With Ignitor Generator and Product-Heat Utilizing Boiler." Silhouette of large pieces of equipment

   Photograph Description: Size, 3 x 4 inches; fair; slick

   Source: Magyar Kemikusok Lapja, Budapest, Vol VII, No 8, August 1952, page 230

   Repository of Source Document: CIA

3. Location: Czechoslovakia, Most, Stalin Works Synthetic Gasoline Plant

   Caption and Description: "CO Conversion. Left, Two Converters; Center, Product-Heat Utilizer; Right, Saturation and Cooling Towers." Silhouette of factory installations

   Photograph Description: Size, 3 x 4 3/4 inches; fair; slick

   Source: Magyar Kemikusok Lapja, Budapest, Vol VII, No 8, August 1952, page 230

   Repository of Source Document: CIA

4. Location: Czechoslovakia, Most, Stalin Works Synthetic Gasoline Plant

   Caption and Description: "Rectification of C_1 -- C_5 Hydrocarbons (Tops of the Columns)." Silhouette of factory installations

   Photograph Description: Size, 2 x 3 inches; fair; slick

   Source: Magyar Kemikusok Lapja, Budapest, Vol VII, No 8, August 1952, page 231

   Repository of Source Document: CIA

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